Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

ESTROUS BEHAVIOR AND STRESS EFFECTS ON THE ESTROUS CYCLE OF RANGE BEEF HEIFERS

K. A. Wagnon · W. C. Rollins · P. T. Cupps · F. D. Carroll

CALIFORNIA AGRICULTURAL
EXPERIMENT STATION

BULLETIN 858
CAEBAD 858 1-16 (1972)

Low conception rates in naturally bred and artificially inseminated range beef cattle led to these investigations of estrous behavior as interpreted by observers in the lots. (For accurate detection of estrus, the authors here place special emphasis on training, motivation, and vigilance.) Attempts also were made to determine if the stress incurred by (1) disturbing the social organization of the heifers, and (2) transporting them to another environment—affected estrus. Results indicated that the normal (15- to 25-day cycle lengths) were not significantly affected by either condition. However, when the nonstress and stress data were combined at each of the two locations of the study, the relative frequency of short cycles was significantly less at Davis, indicating that stress conditions may have been greater at the Field Station. Also, the within-heifer variance of normal cycle lengths was significantly greater at the Field Station than at Davis.

August, 1972

THE AUTHORS:

Kenneth A. Wagnon is Specialist in the Experiment Station and the Department of Animal Science, Davis.

Wade C. Rollins is Professor of Animal Science and Geneticist in the Experiment Station, Davis.

Perry T. Cupps is Professor of Animal Science and Animal Physiology and Physiologist in the Experiment Station.

Floyd D. Carroll is Professor of Animal Science and Nutritionist in the Experiment Station, Davis.

ESTROUS BEHAVIOR AND STRESS EFFECTS ON THE ESTROUS CYCLE OF RANGE BEEF HEIFERS[1]

THE PROBLEM: LOW CONCEPTION RATES IN ARTIFICIALLY INSEMINATED RANGE CATTLE

IN MANY TRIALS, the use of artificial insemination to breed range beef cows, and especially heifers, has resulted in low conception rates. Not the least of several reasons for such low conception is the probable disruption of the normal physiological process of reproduction in cattle by the stresses man inflicts upon the animals with some of his management procedures. In previous years, artificial insemination in this country was used most extensively on horses and, especially, dairy cattle. These animals, for the most part, have been in close association with humans throughout their lives and are well adapted to routine handling, so that they are not unduly nervous in the presence of man. Free-ranging beef cattle, on the other hand, have adapted to a markedly different environment. Their association with humans is more remote, and the treatment they receive now and then, when gathered to be "worked," probably increases their distrust of man. Consequently, these cattle are usually nervous when driven to the corrals and confined, and often become highly agitated when placed in the squeeze-chute.

We do not know of any published evidence that rough handling of the cattle at the time they were inseminated caused a reduction in conception rate. However, Wagnon and Carroll (1966) reported evidence of reproductive losses, including lowered conception rates in some instances, when long-established routines of some range cattle groups were changed. While rough handling was not a factor, the possibility existed that the changing of established routines resulted in periods of stress.

Our interest in this problem was renewed when poor conception rates were obtained from an artificial insemination program at our Sierra Foothill Range Field Station. Purebred and grade Hereford cattle groups of our own breeding that had good reproduction records were moved to the Field Station. At the start of the inseminating period, two mixed-age breeding groups, that had previously been maintained as separate units, were combined and placed in a field adjacent to the working corrals for convenience in heat detection and insemination. Mixing these cattle resulted in a period of social re-organization probably accompanied by stress. These cows had lower conception rates than had a third group of similar animals that was not mixed with other animals, but was bred later. Also, some virgin heifers were transported from our Davis Campus to the Field Station where they were placed in the breeding groups of older animals. The question arose: Did these management practices induce stress and affect estrus and reproduction efficiency?

The study reported here was thus initiated to record estrous behavior as interpreted by observation and to determine if the mixing of strange cows, or the transporting of these animals to a different environment, would causes stresses that would affect estrous behavior or the rhythm of the estrous cycle.

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[1] Submitted for publication December 6, 1971.

PROCEDURAL METHOD FOR THE STUDY

Weaner heifers, mostly of grade Hereford breeding, were purchased each September, from 1966 through 1968, from commercial beef cattle producers in northwestern California. Young heifers were used, because their pretrial history would be more uniform than those of older cows.

At delivery the heifers were about six months old with an average weight of about 375 pounds. Each year, after these calves had recovered from their weaning and shipping stresses, two fairly uniform groups of 33 heifers each were selected, and each animal was branded with an individual identification number. One group was then placed on the University of California Davis campus and the other at the Sierra Foothill Range Field Station, Browns Valley, California. At each location each group was reared separately from other cattle with the objective of promoting normal growth. At Davis the heifers were confined to dry-lots and fed chopped roughage and grain, while those at the Field Station were maintained on the range with supplements when needed or on irrigated pasture with grain. Two of the heifers at Davis died during this initial period of growth.

Each year beginning about July 1, heifers in a given group under study that had reached about 15 months of age and weighed approximately 600 pounds were observed twice daily to detect estrus. Observations were continued until about December 1 with the overall observation period divided into two periods of similar length. Period 1 was used to determine if all the heifers were cycling normally; the heifers were not to be subjected to stresses. At the beginning of period 2, the two initial groups were randomly divided into two or three subgroups, and this same random division was used to report the data from the previous period 1. Treatment of the animals was as follows:

In 1967 only the heifers at the Davis campus were observed. At the beginning of period 2, the group was divided into two equal subgroups. One subgroup was moved into an adjacent smaller lot by themselves; the other subgroup was placed with 42 mature cows so that the stress effects of being dominated by the older, strange animals could be observed.

In 1968 the initial groups at each location were maintained as single groups through period 1. However, at the Field Station the herdsmen inadvertantly rebranded the heifers' identification numbers with hot irons the first day of period 1. This treatment was considered a stress. At the start of period 2, at each location, the initial groups were randomly divided into three equal subgroups. At each location, the first subgroup remained in their respective lots, the second subgroup was moved in with a group of mature cows, and the third subgroup was trucked to the other location (about 70 miles distant) and placed with the first subgroup there. Thus, the third subgroups were subjected to transport stress and a new environment. Since the desired separate quarters for the transported groups were not available at both locations, they were treated alike. However, this may have imposed some stress on the first subgroups, because they had to readjust to the company of their former associates.

In 1969 the same procedures as in 1968 were followed at each location, except the heifers at the Field Station were not rebranded at the start of period 1. At Davis, mature cows were not available to use with the second subgroup, so a larger group of strange heifers of similar age were used; and at both locations the transported groups were placed in separate lots.

Observations to detect estrus were made most frequently between 7:00 and 8:00 A.M. and again between 5:00 and 7:00 P.M. (all daylight saving time) with a minimum observation period of 30 minutes. Some random checks at other times were made when conditions warranted. Care was used in moving about (on foot) among the heifers so as not to disturb them. Since these range-produced animals had not been gentled, and became quite nervous when handled, none were removed to the chute for closer examination. Animals requiring medical treatment, such as for pinkeye or footrot, were moved to the chute shortly after the morning observation period.

In most groups, young vasectomized bulls were used to mark the heifers in heat. Their sternums were smeared with a heavy gear grease into which a red, yellow, or green cement pigment had been mixed. When a vasectomized bull was not available, yearling steers and a nymphomanic cow were used at the Field Station, while at Davis the heifers were observed without the aid of marker animals.

In recording estrus, three categories were used: (1) verification of *standing heats;* (2) *estrous behavior* of the heifer, in addition to possibly being marked; and (3) *marking* as the primary evidence. In the latter case, attempts were made to find some substantiating evidence, such as a sweated appearance or evidence of recent vaginal discharge, since the heifers frequently spread the marking grease from one to another in their mounting activities. In addition to posting the detected heats, logbooks were maintained wherein records of estrous behavior, and other pertinent information, were entered during each observation period.

RESULTS AND DISCUSSION

Estrus detection

Observations for estrus should not be made when the cattle are actively feeding, are disturbed (as from recent handling) —or are distracted by dogs in the lot, movement of other nearby cattle groups, feeding-vehicles, and the like. Hyperactive animals in obvious standing heats may not be difficult to detect under such conditions, but those showing weak manifestations of heat, late stages of estrus or early proestrus—may be hard to detect. Observations were best made when most of the animals were at ease—resting, idling, and ruminating.

It was found best to make the morning observations before the animals were fed or had commenced their morning feeding period, when many were still bedded or idling in the vicinity of their night beds. At this time, those in heat were usually up and milling about. If the animals were accustomed to the observer and his quietly moving among them, vaginal discharges were easier to look for—since many animals had been lying down for a period. If the discharge was a thick string of cloudy or yellowish mucus, she would probably be in estrus within two or three days. On the other hand, if the mucus was thin, clear, and abundant, she would show estrus sooner, if she was not already in heat. Also, such discharges were usually conspicuous on the animals in heat that were actively milling about and mounting others. The amount of mucus discharged by those in estrus was varied; metestrous blood, bright red in color, that often shows 24 to 48 hours after ovulation, was also commonly observed at this time. The hair on the upper part of the tail and below the rear and sides of the pin bones was also checked—as vaginal discharges are frequently smeared over these areas. It was often dry and mixed with other material.

The afternoon observations were also made when most of the cattle were at ease. While vigorous stormy weather was a minor factor in this study, it was more difficult to make good observations during periods of strong winds and driving rains—as they distracted both the animals and observer.

Observer problems. Shortly after the start of this study it became evident that some assistants assigned to check the heifers twice daily were missing some that came into heat, and sufficient effort was not made to substantiate all reported estrus as standing heats. Also, too much reliance was being placed on the marker bull who was not always properly greased. This was probably due to lack of motivation and inadequate training. Consequently, after the first observation period (in 1967) all heat detection at Davis was done by the senior author with some help from another experienced observer.

Results of the poor estrus detection are evident from the combined data from subgroups 67-1 and 67-3 given in table 1. These data, for period 1, show a total of 128 probable heats of which 10 per cent were recorded as "missed," and 59 per cent as "standing heat," 20 per cent were detected by other "estrous behavior," and 11 per cent were "marked" only. Cor-

TABLE 1
OBSERVATIONS FOR ESTRUS AT DAVIS

Subgroup*	Number heifers	Missed	Total recorded	Number of heifers showing: Standing heat	Estrous behavior	Mark by bull	Silent heat	Split cycle†	Treatment
Period 1									
67-1 a	16	6	58	38	12	8	0	0	No induced stress‡
67-3 b	16	7	57	38	13	6	0	0	
68-1 c	11	2	48	43	2	2	1	0	
68-3 d	11	2	49	45	4	0	0	0	
68-5 e	11	0	54	50	1	3	0	0	
69-1 f	10	2	43	41	2	0	0	0	
69-3 g	11	0	49	47	1	0	1	0	
69-5 h	11	0	48	46	1	1	0	0	
Total	97	19	406	348	36	20	2	0	
Period 2									
67-2 a	16	0	50	47	1	2	0	0	No induced stress§
68-2 c	11	4	31	28	3	0	0	0	
69-2 f	10	0	34	31	3	0	0	0	
Total	37	4	115	106	7	2	0	0	
67-4 b	16	4	53	52	0	1	0	2	Mixed with mature cows
68-4 d	11	0	33	32	1	0	0	0	Mixed with mature cows
69-4 g	11	2	33	32	0	0	1	0	Mixed with strange heifers
Total	38	6	119	116	1	1	1	2	
68-12	11	2	33	30	2	0	1	2	Trucked from Field Station
69-12	11	2	36	32	3	0	1	0	Trucked from Field Station
Total	22	4	69	62	5	0	2	2	

* Subgroup numbers followed by matching letters contain the same animals. Subgroups 68-12 and 69-12 had their counterparts at the Field Station.

† Split cycles are those where two successive short estrous cycles combined equal a normal cycle length. Single, short estrous cycles are not included.

‡ Observations made to determine if all the heifers were cycling normally before inducing stress.

§ Subgroup 68-12, associates at time of purchase, placed with group 68-2 probably caused some stress.

TABLE 2
OBSERVATIONS FOR ESTRUS AT FIELD STATION

Subgroup[*]	Number heifers	Missed	Total recorded	Number of heifers showing:					Treatment
				Standing heat	Estrous behavior	Mark by bull	Silent heat	Split[†] cycles	
Period 1									
68-7 a	11	8	44	35	0	9	0	2	Hot-iron branded[‡]
68-9 b	11	14	38	35	1	2	0	0	
68-11 c	11	9	45	42	0	3	0	0	
Total	33	31	127	112	1	14	0	2	
69-7 d	11	9	46	44	1	1	0	4	No induced stress[§]
69-9 e	11	8	43	42	1	0	0	0	
69-11 f	11	3	45	39	5	1	0	0	
Total	33	20	134	125	7	2	0	4	
Period 2									
68-8 a	11	2	34	31	0	3	0	2	No induced stress[¶]
69-8 d	11	14	19	19	0	0	0	0	No induced stress
Total	22	16	53	50	0	3	0	2	
68-10 b	11	10	24	21	2	0	1	2	Mixed with mature cows
69-10 e	11	15	20	20	0	0	0	0	Mixed with mature cows
Total	22	25	44	41	2	0	1	2	
68-6	11	1	36	33	0	3	0	8	Trucked from Davis
69-6	11	6	36	30	1	5	0	2	Trucked from Davis
Total	22	7	72	63	1	8	0	10	

[*] Subgroup numbers followed by matching letters contain the same animals. Subgroups 68-6 and 69-6 had their counterparts at Davis.

[†] Split cycles are those where two successive short estrous cycles combined equal a normal cycle length. Single short estrous cycles are not included.

[‡] Induced stress resulting from the branding with hot irons was not a part of the study.

[§] Observations made ot determine if all the heifers were cycling normally before inducing stress.

[¶] Subgroup 68-8, associates at time of purchase, placed with this group probably caused some stress.

responding data on criteria for recognizing estrus from the same heifers (combined subgroups 67-2 and 67-4, with the latter stressed) collected by one of us in period 2 were 4 per cent “missed,” 92 per cent as “standing heat,” 1 per cent by other “estrous behavior,” and 3 per cent “marked,” from a total of 107 probable heats. Heat detection at the Field Station was done by several observers who were too far removed to be directly supervised from Davis. From the data given in tables 1 and 2 it is evident there was variability in the abilities of the different observers.

It is possible to accurately detect estrus by observations. Donaldson (1968) in a study of several methods of estrus detection in cattle found he was able to detect 90 per cent of the heats with observations only at 7:00 A.M. and at 4:00 P.M. When the bull’s sternum and forelegs were smeared with a colored oil, he detected 98 per cent of 47 heat periods in 39 cows. In another study subsequent to the one reported here, with 31 heifers of similar age to those in the present study, with all receiving normal treatment, the senior author observed 124 standing heats, seven heats detected from other behavior, and one missed heat from a probable 132 heats. Of the seven heats recorded from behavior, other than standing heat, five were later marked by the bull. The one missed heat was considered silent, because of the heifer's behavior noted at the time her estrus was due.

Accurate detection of estrus was essential to the present study—if stressing was the cause of missed heats, abnormal heats, and irregular estrous cycles.

Silent heats. Since Hafez and Lindsay (1965) reported a high incidence of quiet ovulations in beef cattle after transportation, we were interested in the possibility that our induced stresses would cause silent heats. At Davis, five silent heats were recorded out of 742 probable heats; and at the Field Station, one silent heat was recorded out of 529 probable heats. Evidence that quiet heats had occurred was the external appearance of metestrous blood. In only one of these was there prior suspicion that the heifer was undergoing silent heat. Another heifer was recorded as missed because we were unable to detect a subsequent discharge of blood. The presence of metestrous blood is evidence that an ovulation has occurred. But its presence can be missed easily during the brief observation periods and cannot, therefore, be used as the means to detect silent heats. Also, there was evidence of considerable variability in the amounts of blood discharged, and it is not known if observable amounts are discharged after all ovulations. Thus, it is not known what percentage of the estrous periods reported missed were actually silent heats. However, at Davis, after deleting the data from the initial observation period, the data showed that a higher incidence of missed heats occurred during the stress periods than in the nonstress periods (table 1). Our observation methods were not adequate for detecting silent heats.

Duration of estrus. Duration of estrus has long been known to vary from 6 to 30 hours, but on the average it is about 18 hours (Hammond, 1940). According to Hafez and Schein (1962), the duration of normal estrus is dependent upon geographical locality, breed and age of cattle, with the length of the heat periods of heifers shorter than that of cows. While we did not seek to collect information on the duration of estrus, our data tend to support the observations that heat periods of cattle do vary widely.

Out of 415 recognized heats (at Davis for 1968 and 1969), 65.8 per cent were already in estrus (mostly standing heats) when first observed, with the remaining 34.2 per cent exhibiting recognized proestrous behavior. A slight majority of 51.6 per cent were first seen in estrus at the morning observation periods; of these, 57.9 per cent had gone out of heat by the following afternoon observation periods with less than 1 per cent still in heat the next morning. Of the 48.4 per cent first seen in estrus at the afternoon periods, 77.6 per cent had gone out of heat by the following morning observation periods; only about 0.5 per cent were still in heat the second afternoon. From the Davis data (table 1), after eliminating subgroups 67-1 and 67-3, out of a total of 594 recorded heats, only nine were detected by being marked. These heifers apparently had short heat periods between the afternoon and ensuing morning observation periods.

Behavior

The information presented here was summarized from entries in the Davis logbooks and from the logbook of another study, similar to the present one, but without stresses as a factor. While all the heifers were closely observed during the observation periods, once the study was underway, the observer was well aware when most subsequent heat periods were due and consequently looked for proestrous behavior. However, some animals had such weak or vague manifestations of estrus (Rottensten and Touchberry, 1957) that heat detection was difficult, particularly when the daily observation periods were so brief and were made at all stages of estrus. Most of the observa-

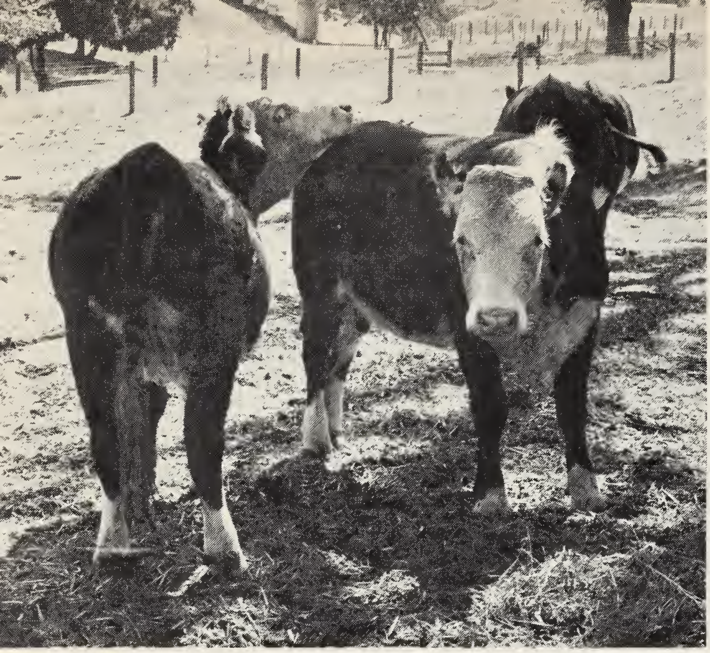

Fig. 1. The heifer on the right is in estrus. She stopped her wandering search for attention when the heifer loafing nearby placed its chin on her rump, indicating an intention to mount.

tions were made when the heifers were not distracted by such activities as feeding, movement of dogs about the animals, or were still nervous from recent handling or similar disturbances.

Proestrous behavior. About 34 per cent of the heifers were seen displaying proestrous behavior. For the most part this behavior was exhibited 10 hours or less just before they came into standing heat. The earliest proestrous behavior that was recognized was above average aggressiveness in butting other heifers and in movement without evident purpose about the lot. In time, when she is not lying down or eating, the heifer's nervousness gradually increases until she is actively roaming about the lot (wanderlust)—sometimes breaking from a hurried walk into a short run as she moves from one boundary fence to another. During this period she may also stand at one boundary fence or another, looking at cattle in nearby pens or fields. Frequently, such a heifer bawls (lost-soul bawl) which sounds as if she is lost or separated from other animals, even though she is walking or standing among the other heifers in the lot. The heifer's associates, even the bull at times, usually show no interest in her condition. At this stage these heifers are more alert and usually the first to note the movement of nearby animals or humans outside the lot.

As these nervous heifers approach estrus, they commence smelling the genitalia of some of their associates (including the bull), especially those that have recently been in heat, and attempt to mount some of them. However, they themselves refuse to stand when mounted. The resulting milling-about usually increases in tempo, until the heifer reaches standing heat.

Estrous behavior. The average heifer reaching normal estrus, and hyperactively milling about in attempts to mount her consorts and being mounted by them, usually will stop milling about and stand quietly if another animal rests its chin on her back or rump (see fig. 1); or the bull indicates his intention to mount her by giving her a vigorous lick with his tongue on her shoulder. When first mounted she stands firm, even bracing herself if necessary, unless she is mounted abnormally from the side or over the head. Heifers in estrus that have been repeatedly mounted may not stand well because of fatigue, and, in some instances, they will collapse when their hind legs give way.

The milling about of heifers in estrus with those not in heat or in proestrus leads to confusion at time in detecting which ones are actually in estrus. This is especially true when there may be one or more hyperactive heifers involved with less active females, all in standing heats, and the marker bull shows interest in only one of the heifers throughout the observation period. There were also times when the most active heifers in the mill-around were not the ones in heat.

There were occasions when several heifers, in various stages of their estrous periods, would be milling about and mounting each other. The bull might also be involved in this activity, but in the process completely ignore a particular heifer obviously in heat and seeking attention (nuzzling another heifer about the neck, shoulder, and the like). Usually, if not driven away, such an ignored heifer actively mounted others in estrus. But when she positioned herself to be mounted in front of another heifer, the second heifer would butt her aside or walk around her. Or, if she moved in front of the bull, he might give her a couple of licks with his tongue on her shoulder with a low utterance. Then losing further interest in the heifer the bull would take off after one of the favored heifers in heat. Some of these ignored heifers completed their estrus unmarked and without our obtaining positive proof they were in standing heat. If the manifestation of estrus were weak, proof of standing heat was especially hard to obtain.

Sometimes, one of these ignored heifers in heat would exhibit the wanderlust and lost-soul bawl as in proestrus behavior, except that she was actively seeking attention. Often these heifers would be found marked at the following observation period.

Heifers in estrus do not continuously exhibit estrous behavior throughout their heat periods. There are periods of feeding, ruminating, and resting that may occur during the observation period. In a few instances, heifers quietly standing idle, or feeding, stood firm when mounted by another heifer that was passing by.

Silent heats. When silent heats were suspected to be in progress, some heifers exhibited isolated clues to their condition. One heifer, for instance, exhibited above average nervousness while at the feed manger. In addition, while she stood eating, she stamped her hind feet hard several time and vigorously switched her tail. While marked switching of the tail (as opposed to a casual, relaxed switching) may be an indication of nervousness, we made no special note of it because of a heavy infestation of houseflies. Another heifer appeared to be above average in aggressiveness; while a third followed a non-estrous heifer about and rested her chin on her companion's rump (see fig. 1) a few times, as if to mount her. All these actions were transitory, and none of the other animals showed the least interest in them during the entire observation period.

Bull behavior. Kerruish (1955) stated that under certain conditions, a bull is able to detect a proestrous cow two to three days prior to the onset of estrus. On a few occasions in our lot studies we thought the marker bull was showing unusual interest in a heifer, in whom we could not detect any evidence of proestrous behavior. Some of these heifers did come into heat within a day or two, while others did not show any evidence of estrus within the three following days. We have no evidence the bull was aware that a heifer was undergoing silent heat.

A common activity of the bull, which we could not associate with proestrus or estrus, was his smelling the urine of the heifers. He may thrust his nose into the urine stream of a heifer, lick fresh urine from the ground, or, without her apparent objection, rub his nose and lick with the tip of his tongue the lower tips of the female's vulva causing her to discharge a few drops of urine. After obtaining the urine, the bull extends his neck and head horizontally, with his head slightly raised, curls back his upper lip exposing his teeth, and audibly breathes through distended nostrils. He may "investigate" more than one heifer in this manner, then move on. A bull will usually stop an activity he is engaged in, to walk over and smell a nearby cow he sees or hears urinating. These females are usually nonestrous. Limited observations indicated that experienced bulls turned into an adjacent small lot or field containing several heifers, among which were a couple in heat, went directly to those in heat and bred them without any preliminary investigation or courtship—they undoubtably were aware of these heifers in heat.

As stated above there were occasions when a heifer in estrus was ignored by the bull because he had become attached to another heifer in heat. He usually followed the favored heifer about and tried to keep other heifers from mounting her. This discrimination by the bull did not exist at prior or subsequent heat periods of the ignored heifer.

In a few instances, the bull showed some interest in a heifer just starting to show proestrous behavior. He would follow her about and lie down (often head to tail) alongside her when she bedded down. In these cases, no sexual activity in the group had occurred for two or three days, so the bull's libido was not at a low ebb from recent breeding activity. However, his attention at this time was easily diverted by another heifer urinating nearby or sexual activity in a nearby lot. When a marker bull remains continuously with a group of heifers, with several coming into estrus in succession, his libido and breeding efficiency will deteriorate, and he will sometimes appear to ignore heifers in heat. We must remember that only a small portion of the bull's daily activities were scrutinized in our observations, and it is possible (especially, if the bull was experienced) that he had already bred the heifer and was no longer interested in her.

In this study there were many times when the marker bull (all from our closed line of Hereford breeding) would herd all the heifers (see fig. 2) into a close group for a period, usually away from a gate or division fence with other bulls on the opposite side. When he was gathering them and a heifer did not move, when he snorted at her with lowered head, he would butt her roughly. After grouping them, he would not allow any to go to feed, salt, or water. However, there were times when some of the heifers gave him considerable trouble, because they would try to escape from the group to engage in one of the previously stated activities. If necessary, he would run at full speed to head off an escaping heifer. None of these heifers were in heat; but once a heifer in the wanderlust stage of proestrous behavior made it almost impossible for the bull to keep his heifers grouped. A mature marker bull sometimes herded his cows towards a common night bed.

Effects of stress

The authors are not aware of previously published data on the length of the estrous cycle of beef heifers when breeding was not involved. Figures 3 through 6 show the distribution frequencies of estrous cycle lengths for the nonstressed and stressed subgroups at Davis and at the Field Station. From these histograms, it is evident that in each of the four treatments, there was a central class of normally distributed cycles from about 15 to 25 days in length. Furthermore, each of

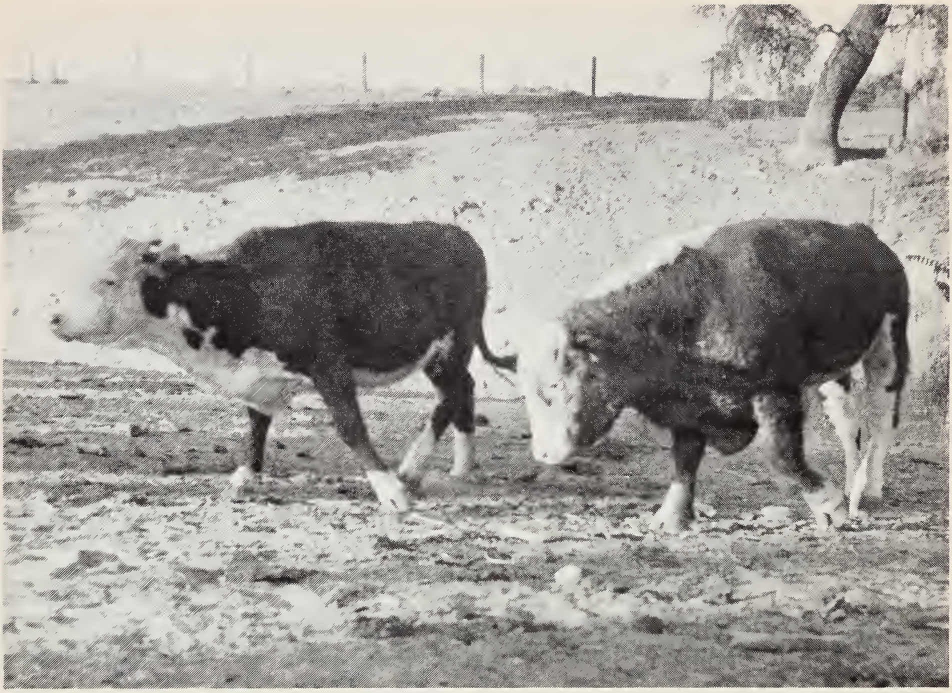

Fig. 2. The marking bull herding a heifer into a common grouping. The dark color of his brisket is due to colored marking grease.

the distributions show cycle lengths shorter than 15 days, and one histogram of the Field Station data shows cycles longer than 25 days. In their study of variation in the sexual cycle of dairy cattle Chapman and Casida (1937), found that when the central class of cycles (17 to 27 days) were analyzed it was found that each animal, on the average, had a very definite individuality in cycle length. They also believed that extremely short and silent heat periods were respon-

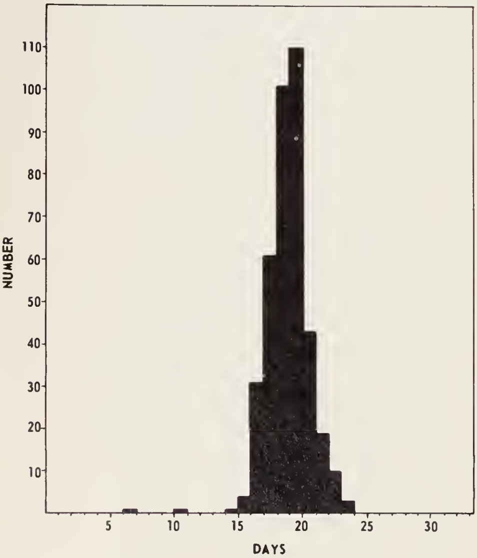

Fig. 3. Distribution of 386 estrous cycles of non-stressed heifers at the Davis campus.

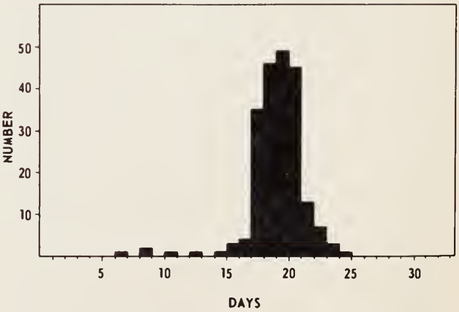

Fig. 4. Distribution of 212 estrous cyles of the stressed heifers at the Davis campus.

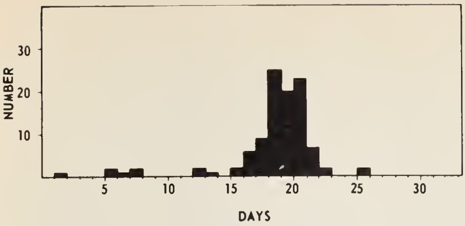

Fig. 5. Distribution of 105 estrous cyles of non-stressed heifers at the Field Station.

sible for what might be termed "observational error." The development of heat detection devices (which are continually being improved), and the use of vasectomized bulls, since Chapman and Casida's study should have greatly reduced errors in observations.

Short heat periods, short estrous cycles, and silent heats (which we usually could not detect) all occurred in the present study. However, we were not able to measure estrous period lengths. Thus, we do not have data on the frequency of short estrous periods or silent heats. Two types of short estrous cycles (less than 15 days) occurred: (1) singly between normal cycles, and (2) in pairs. These pairs of short cycles were considered "split cycles," because when combined they equaled the length of one normal cycle (see tables 1 and 2). An example of the occurrence of split cycles is shown by the following recorded heat cycles (days) for a heifer for both periods 1 and 2: 18-13-6-13-8-20-21-21-21. All were standing heats.

Distributions of raw data and results of routine analysis of variance suggested two measures of stress effects (Wagnon *et al.*, 1972):

(1) the relative frequency of short cycles (less than 15 days); and

(2) the within-heifer variance of cycle lengths (for normal cycle lengths).

Each of the four distributions of cycle lengths (figs. 3 to 6) appears to be normally distributed within the range 15 to 25 days, which in this analysis will be considered the normal range, and rectangularly distributed at less than 15 days. Figure 6 appears to show a rectangular distribution for cycle lengths of 26 days or more. These longer cycles could be sums of pairs of cycles (one of normal length plus a short one) when the estrous period between was a silent heat or an estrous period missed by the observer.

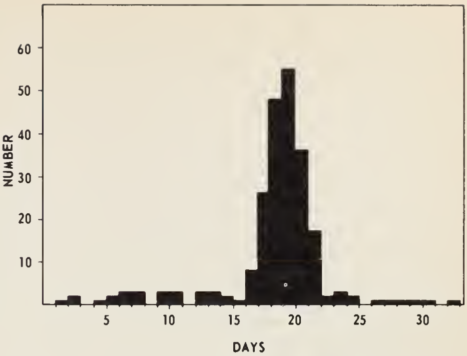

Fig. 6. Distribution of 230 estrous cycles of stressed heifers at the Field Station.

The tests of normality in table 3 (Bliss, 1967) for the distributions in the range of 15 to 25 days generally support an hypothesis of normality, and the ratio of range to standard deviation (see iii) suggests that arbitrary truncation at 15 and 25 days has not introduced gross inaccuracies into the analysis.

As shown in table 4, the relative frequency of short cycles to normal was higher under stress conditions both at Davis and at the Field Station. However, in neither case did the difference approach the 5 per cent level of statistical significance. On the other hand, the relative frequency of short cycles to normal at Davis (stress and nonstress periods combined), 8/590 = .014 was significantly less than the corresponding item, 33/294 = .112, at the Field Station ($P<6\times10^{-7}$). Table 5 provides additional such evidence: data from group A, which spent period 1 at Davis and period 2 at the Field Station, and from group B,

TABLE 3
DISTRIBUTIONS OF ESTROUS CYCLES OF RANGE CATTLE, STRESSED AND NONSTRESSED, WITHIN THE 15- TO 25-DAY RANGE

Item	Location and treatment			
	Davis		Field Station	
	Nonstressed (fig. 3)	Stressed (fig. 4)	Nonstressed (fig. 5)	Stressed (fig. 6)
Sample size	383	207	94	200
Mean (days)	19.4	19.8	19.7	19.8
Standard deviation (days)	1.49	1.59	1.50	1.59
Range (days)	9	10	7	10
*Tests of normality**				
(i) Kurtosis	N.S.	N.S.	N.S.	Leptokurtotic (.05>P>.01)
(ii) Skewness	Positive skewness (P = .02)	N.S.	N.S.	N.S.
(iii) Ratio of range to standard deviation	N.S.	N.S.	N.S.	N.S.

* Bliss (1967). N.S. = Not significantly different from a normal distribution at the .05 level.

which spent period 1 at the Field Station and period 2 at Davis.

Estimates of the within-heifer variance of normal cycle lengths (15 to 25 days) did not differ significantly between stress and nonstress periods at either Davis or the Field Station. However, when stress and nonstress periods were combined at each location, the estimate was significantly smaller at Davis than it was at the Field Station. The level of the significance of the difference was approximately P = .025, if one tests the null hypothesis that the within-heifer variance of normal cycle lengths was not larger at the Field Station than at Davis; or the level of significance of the difference is approximately P = .05, if one tests the alternative null hypothesis that there is no difference between vari-

TABLE 4
FREQUENCIES AND RELATIVE FREQUENCIES OF NORMAL AND SHORT ESTROUS CYCLE LENGTHS OF RANGE CATTLE, STRESSED AND NONSTRESSED

Location and treatment	Frequencies and relative frequencies of cycle lengths		
	Short (a)	Normal (b)	(a/b)
Davis—nonstressed	3	383	.008
Davis—stressed	5	207	.024
Field Station—nonstressed	9	94	.096
Field Station—stressed	24	200	.120

TABLE 5
FREQUENCIES OF NORMAL AND SHORT CYCLE LENGTHS OF TWO GROUPS—ONE (A) OBSERVED FIRST AT DAVIS (PERIOD 1), THEN AT THE FIELD STATION (PERIOD 2); THE OTHER (B) OBSERVED FIRST (PERIOD 1) AT THE FIELD STATION, THEN AT DAVIS (PERIOD 2)

Location, cattle group, and period	Frequency of cycle lengths		
	Short (a)	Normal (b)	(a/b)
Davis			
Group A (period 1)	2	78	.026
Group B (period 2)	2	66	.030
Total (A + B)	4	144	.028**
Field Station			
Group A (period 2)	10	59	.169
Group B (period 1)	5	59	.085
Total (A + B)	15	118	.127**

** Significance of difference (P<.01).

ance of normal cycle lengths at each location.

The corresponding estimated standard deviation of within-heifer cycle lengths for Davis and the Field Station were 1.23 days and 1.38 days, respectively, or 29 hours and 33 hours.

There was no evidence of stress effects on the means of the normal class of 15- to 25-day cycle lengths, which varied from 19.4 to 19.8 days between the four treatments. Note that the distribution of cycle lengths for the Davis non-stressed heifers, which were considered to have been made under normal conditions, is quite similar to that given for dairy heifers by Asdell, de Alba, and Roberts (1949; fig. 1, middle).

In the light of the hypothesis that increased frequency of short cycles is an indication of stress, note that both at Davis and at the Field Station, the frequency of short cycles was higher during the stress periods than during the nonstress periods. While in neither case were these differences statistically significant, they assume some importance in view of the highly significant greater number of short cycles (mostly due to split cycles) at the Field Station than at Davis. This view is further enhanced by the data resulting from the reciprocal transport of groups A and B between Davis and the Field Station (table 5).

In addition, at Davis (after removal of subgroups 67-1 and 67-3 and transferring subgroup 68-2 to the stressed groups) the number of missed heats increased in the stressed groups as compared with those in the nonstressed groups (table 1). If these missed heats were silent heats, then stress may be considered to have increased the incidence of silent heats. There is evidence (for example, subgroup 69-8, table 2) that some observers at the Field Station may have overlooked actual heats, since the total of 18.7 per cent missed heats at the Field Station is so much greater than the total of 4.5 per cent of missed heats at Davis.

Why the combined groups at Davis (stressed and nonstressed) were significantly different from the similarly combined groups (for our hypothetical measures of stress) at the Field Station is unknown. The statistical results under discussion suggest that there are greater stresses, possibly of long-time duration, under the range conditions at the Field Station than under the farm conditions at Davis. In the opinion of the authors this supposition warrants further study and experimental investigation.

SUMMARY

When observers were adequately trained, motivated, and vigilant, the twice-daily observations (30 minutes minimum each for morning and afternoon) of range-produced beef heifers were enough to provide highly accurate detection of the often subtle behavioral changes associated with proestrus, estrus, and metestrus. Observavations were best made when both the cattle and the observer were undistracted, with most of the cattle at ease—resting, ruminating, and idling. A vasectomized marker bull helped the observer to detect animals in estrus, but the bull could not be depended on to detect all heifers in heat.

Characteristic behavior was reported for proestrous and estrous periods, with proestrus recorded for 34 per cent of the observations. Sometimes, however, behavior was similar for both periods. Estrous and proestrous behavior varied from noticeable hyperactivity to a mild restlessness that might easily pass unnoticed. Estrous behavior was not constant throughout the heat period, and it varied between animals. Also, the periods were broken by intervals of feeding, ru-

mination, and rest, during which estrous behavior may have been absent.

The established 15- to 25-day cycle lengths (which varied from 19.4 to 19.8 days) were not significantly affected when heifers were placed with strange, mature cows, or transported from one environment to another (reciprocal movements between the Davis campus and the Field Station).

However, when the nonstress and stress data were combined at each location, the relative frequency of short cycles was significantly less at Davis, indicating that stress conditions may have been greater at the Field Station. Also, the within-heifer variance of normal cycle lengths (15 to 25 days) was significantly greater at the Field Station than at Davis.

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7½m-8,'72(Q1880L)P.A.D.

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